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INFLUENCE OF DIFFERENT MICROWAVE SEED ROASTING PROCESSES ON THE COLOR VALUES OF TEHINA (SESAME PASTE)

SUSAM KAVRULMASINDA FARKLI MİKRODALGA UYGULAMALARININ TAHİN RENGİ ÜZERİNE ETKİSİ

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ABSTRACT: The moisture content and L, a, b color values of tehina prepared by roasting the sesame seed for different exposure periods (3-50 min) and seed depth (1-2 cm) at different powers (399, 665, 931, 1330 W) of a domestic microwave oven (2450 MHz) were determined. Results were compared with those obtained for sesame roasted by the conventional method. The color of sesame seeds changes gradually during microwave processing. L color values decreased for all power levels with increasing exposure time, a and b values increased. L color values of tehina obtained from microwaved seeds at different power levels and exposure times and seeds depths were between 40.78-61.37. Similarly, a color values were between 1.00 - 12.31 and b color values between 16.41 and 24.86. Results showed that microwave oven roasting markedly reduced the roasting time in tehina production with respect to conventional method.

Key Words: *Sesamum indicum*, tehina, microwave, roasting, color

ÖZET: Ev tipi mikrodalga fırının farklı güçlerinde (399, 665, 931, 1330 Watt) ve her güçte farklı sürelerde (3-50 dak.) ve farklı yığın yüksekliklerinde (1-2 cm) kavrulan susamlardan elde edilen tahinin rengi geleneksel yöntemle üretilen örnekle karşılaştırılmıştır. Susam tohumlarının rengi mikrodalga işlemi ile değişik düzeylerde değişmiştir. L renk değerleri uygulanan tüm güç seviyelerinde sürenin artışına bağlı olarak azalmış, a ve b değerleri ise artmıştır. Mikrodalga ile kavrulan susamların farklı güç, süre ve ürün yığın yüksekliğine bağlı olarak L değeri 40.78-61.37, a değeri 1.00-12.31 ve b değeri 16.41- 24.86 arasında değişmiştir. Sonuçlar, tahin üretimi amaçlı susam kavrulmasında mikrodalga uygulamasının kavurma süresini önemli oranda kısalttığını göstermiştir.

Anahtar Kelimeler: *Sesamum indicum*, tahin, mikrodalga, kavurma, renk

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the world's most important oil seed crops and it is produced mainly in India and China (1). Sesame seed is used extensively in the production of edible oils. Not only is it a source of edible oils, the seed itself provides a nutritious food source for human consumption. Sesame seed is also used in baked goods and confectionery products (2, 3). In some Eastern countries sesame seed is used mainly for preparing tehina (a sesame paste product similar to peanut butter) and halva (4).

Tehina is generally served as an appetizer or dressing, after being sweetened with pekmez, honey and sugar syrup or hydrated with 1-2 volumes of water in order to form a thin oil in water emulsion (5). The conventional method for preparing tehina involves cleaning, dehulling, roasting and grinding sesame seed. Since roasting significantly increases overall palatability of oil seeds by enhancing their flavor, color and texture (6), roasting is the key step for making tehina.

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Appearance is the primary factor that determines the acceptance or rejection of a food. Thus obtaining the desired color at the end off the process is a challenge for processors. The changes in product properties associated with processing are mainly related to drying and non-enzymatic browning during roasting. The possibility of enzymatic browning is low, since the enzymes responsible for enzymatic browning are denatured very early in the process due to high temperatures employed during roasting (7). Fallico et al. (8) investigated the color development during roasting of hazelnuts. They found that roasting temperature and exposure time were the main factors, affecting color development during roasting of hazelnuts.

The color formation in sesame oil could be attributed to both non-enzymic browning and phospholipid degradation during roasting (3). Color formation in sesame oil was dependent on the extent of roasting (9).

The conventional method for roasting sesame seeds is to roast seeds in a rotating cauldron on a gas flame for about 4-5 hours.

Microwave ovens are an energy efficient means of heating and a rapid method for reheating of foods (10, 11). Microwaves have great penetrating power, and food products heated by them have little temperature gradient. Materials containing polar molecules are rapidly heated, when exposed to microwave radiation, due to molecular friction generated by dipolar rotation in presence of an alternating electric field (12). The application of microwave processing for both home and institutional meal preparation has increased because of its speed and convenience (13, 14, 15).

Few studies concerning the influence of roasting on composition and quality of sesame oil have been reported (3, 9, 16, 17). Moreover, little has been reported about how microwave roasting affects the quality of the sesame seeds and tehina oil (18, 19, 20). To our knowledge, there are no reports on the effect of different microwave power levels and exposure periods on the color of tehina.

The objective of this study was to investigate the change in color and moisture content of tehina produced from sesame seeds which were roasted at two different seed depth and three different exposure periods at different power levels of a domestic microwave oven.

MATERIALS AND METHODS

The sample of sesame seeds (*Sesamum indicum* L.) in this study was a white species which was grown in Antalya, Turkey. Seeds were purchased from a local store during harvesting season.

Preparation of tehina: Tehina was prepared by cleaning, dehulling, drying, roasting and grinding the sesame seeds. The seeds were soaked in water for 8 hours, dehulled by mechanical abrasion, and separated from the hulls by flotation in brine (5% salt solution, w/v). After washing with water to remove the salt, the dehulled wet sesame seeds were spread on the laboratory bench at a depth of 1 cm and left to dry at ambient conditions. Dried seeds were spread on the Pyrex® plate of a domestic-size Beko microwave oven (BKMD 1550, Turkey) capable of generating 2450 MHz at 1330 W power. The microwave oven used operates at a frequency of 2450 MHz, with 1330, 931, 665 and 399 W of output corresponding to power levels of high, medium high, medium and defrost, respectively. Each time the plate of the microwave oven contained about 180 grams of seeds with a depth of 1 cm, and about 360 grams of seeds with a depth of 2 cm. For comparison purposes, conventionally roasted sesame seeds were obtained from a local tahineh processor. The conventional roasting was performed in a rotating cauldron heated by gas for 4 hours.

After roasting, the seeds were allowed to cool to ambient temperature before being processed into tehina. The experimental design for this study is shown in Table 1.

For production of tehina, each sample of dehulled and microwaved seed was ground in a Waring blender. To cool the seeds when they were being ground, cold water was placed around the blender in plastic bags. Seeds were ground for 30 s followed by a quiescent period of 2 minutes. This process was repeated 6 times to prepare the paste known as tehina. Subsequent analyses were carried out on the paste. Tehina samples were stored in glass jars in a dark room.

Table 1. The experimental design applied for microwave roasting of sesame seeds.

Depth of seed	1 cm				2 cm			
Power (Watt)	1330	931	665	399	1330	931	665	399
Exposure time (minute)	3, 4, 5	4, 6, 8	10, 12, 14	30, 40, 50	3, 4, 5	4, 6, 8	10, 12, 14	30, 40, 50

Moisture content determinations were carried out according to procedures outlined in AOAC (21).

Color measurements: Hunter a, b and L parameters were determined with a Minolta CR 200 spectrophotometer (Minolta Camera Co., Japan) in the reflection mode. The spectrophotometer was standardized with a white ceramic plate. The L, a and b values are the three dimensions of the measured color which gives specific color value of the material. The L value represents the ligth-dark spectrum with a range of 0 (black) to 100 (white), the a value represents the green-red spectrum with a range of –60 (green) to +60 (red) while the b value represents the blue-yellow spectrum with a range of –60 (blue) to +60 (yellow) (7). The net color difference (ΔE) was calculated from the a, b and L parameters, using the equation:

$$\Delta E = (\Delta a^2 + \Delta b^2 + \Delta L^2)^{0.5} \quad (1)$$

Where $\Delta a = a - a_0$, $\Delta b = b - b_0$, $\Delta L = L - L_0$; for the calculation of color difference between processed samples and the conventionally processed tehina color (DE1), subscript "0" indicates conventionally produced tehina color; for the calculation of color difference between processed samples and dehulled ground raw seeds (DE2), subscript "0" indicates dehulled ground raw seed color. Color was determined two times in duplicate tehina samples.

The hue angle (h) and chroma (C) were also calculated as described by Seve (22);

$h = \arctan (b/a)$ (2)

$C = (a^2 + b^2)^{0.5}$ (3)

Tehina preparation was replicated two times, chemical and instrumental measurements were duplicated, and mean values were reported. Analysis of variance (ANOVA) ($p<0.01$, $p<0.05$) and Duncan's multiple range test ($p<0.05$) were performed to evaluate the significance of differences between values. Standard deviation values of the means were also calculated.

RESULTS AND DISCUSSION

In tehina production, after the dehulling step, the seeds were roasted to reduce moisture content below 1.50% (23) and also to obtain a desirable flavor. The moisture content and color values of tehina produced from sesame seeds roasted in the microwave oven at four power levels (1330, 931, 665 and 399 W) and at different exposure times (3 to 50 min) in each power level with a 1 and 2 cm seed depth, is summarized in Table 2.

Table 2.

The moisture content of tehina obtained from microwaved seeds at different power level and exposure times were between 0.09-1.66%. The moisture content of tehina obtained from conventionally roasted seeds was 0.13% (Table 2). ANOVA showed that there were significant differences in moisture contents ($p<0.01$) between different exposure times at each microwave power level as well as depth of seed.

When the microwave oven power was decreased from 1330 W to 399 W, the moisture content of the samples also decreased. Although sensory analyses were not carried out, it could be stated that according to observations, the sample obtained by roasting at 399 W microwave oven power did not have the typical tehina flavor. Additionally, when the exposure time was increased, the moisture content of tehina decreased. Our results agree with those of Yosida & Takagi (24), who found that, the higher the roasting temperature and the longer roasting time, the greater the rate of the moisture loss of sesame seeds.

Table 2. Mean color values of tehina obtained from seeds roasted at different power levels and exposure times roasted at different depths using a microwave oven and the conventional method.

Seeds Depth	Power (Watt)	E. Time* (minute)	% Moisture	Color values						
				L	a	b	h	C	DE1	DE2
	Raw		6.81	72.43	0.23	19.02			11.71	-
	Conventional		0.13	53.83	3.23	15.75	78.41	16.08	-	11.71
		3	1.03	60.76	1.19	18.83	86.38	18.87	7.85	13.04
	1330	4	0.49	59.59	1.99	20.42	84.43	20.52	7.52	19.23
		5	0.30	55.00	5.86	24.86	76.74	25.54	9.55	13.90
		4	0.96	59.00	2.91	21.38	82.25	21.58	7.65	17.15
	931	6	0.46	56.37	4.47	23.28	79.13	23.71	8.04	20.80
		8	0.23	53.55	6.74	24.85	74.82	25.75	9.76	21.92
1 cm										
		10	0.77	52.39	7.55	24.03	72.56	25.19	9.45	21.60
	665	12	0.40	52.69	7.00	24.60	74.12	25.58	9.69	29.29
		14	0.15	45.64	11.09	23.74	64.96	26.20	13.88	19.17
		30	0.25	54.77	6.26	23.40	75.02	24.22	8.28	25.58
	399	40	0.17	48.85	9.36	22.88	67.75	24.72	10.64	33.88
		50	0.09	40.78	12.31	19.46	57.68	23.03	16.33	74.89
		3	1.66	60.29	2.00	17.84	83.60	17.95	6.90	12.02
	1330	4	1.16	60.53	1.71	18.14	84.61	18.22	7.27	11.50
		5	1.10	61.25	1.00	16.46	86.52	16.49	7.78	16.28
		4	1.12	56.63	3.39	21.32	80.97	21.59	6.24	11.80
	931	6	0.87	60.76	1.00	17.46	86.72	17.49	7.48	11.84
		8	0.69	60.72	1.62	17.93	84.84	18.00	7.40	11.15
2 cm										
		10	0.91	61.37	1.36	18.19	85.72	18.24	8.14	12.77
	665	12	0.58	59.79	2.04	18.79	83.80	18.90	6.80	17.09
		14	0.35	56.65	4.91	23.62	78.26	24.12	8.53	11.44
		30	0.57	61.32	1.00	16.41	86.51	16.44	7.84	11.88
	399	40	0.45	60.82	1.15	16.68	86.06	16.72	7.35	13.21
		50	0.21	59.49	2.59	20.21	82.70	20.38	7.23	74.89

***E.Time:** Exposure time

There is a limitation to the depth that microwaves can penetrate and heat the food material. This limit may vary according to the food composition. For a 2450 MHz microwave oven frequency, appropriate material depth, was mentioned to be approximately 13 mm (25). The moisture content of the sample from the seeds roasted in depth of 2 cm were higher than those roasted in the depth of 1 cm. The moisture content of tehina from microwaved seeds was always higher than tehina prepared by the conventional method except for one of the applications (Table 2). There have been some reports on acid value, degree of oxidation and fatty acid composition of sesame oil obtained by roasting with the classical method and electric oven as well as microwave oven (3, 9, 23). However, very few studies has been carried out to determine tehina quality characteristics. Appearance is very important for the consumer and one of the most important quality parameters for tehina is color. Color development during roasting depends on the food composition as well as the roasting conditions.To our knowledge, no studies have been carried out determining color development during processing of tehina.

Significant differences in color parameters were found between the unroasted (raw) and roasted samples. The unroasted sample was the ligthest as shown by the highest L value (72.43) and the lowest a value (0.23). The color of sesame seeds changes gradually during microwave processing. The main changes were observed in the L and a values. The yellow component (b value) of the samples remained almost constant during roasting. The L color values of tehina obtained from microwaved seeds at different power levels and exposure times and seed depths were between 40.78 and 61.37. Similarly, a color values were between 1.00 and 12.31 and b color values between 16.41 and 24.86. The hue angle and chroma values of the sample ranged between 57.68-86.52 and 16.44-26.20 respectively. The L, a, b, hue angle and chroma values of tehina obtained from conventionally roasted seeds were 53.83, 3.23, 19.02, 78.41 and 16.08 respectively (Table 2). ANOVA indicated that there were significant differences ($p<0.01$) between different exposure time at each microwave power and also depth of seed for L, a and b color values except for exposure period at 399 W for b value ($p>0.05$).

Duncan's multiple comparison test also showed that, exposure time and depth of the seeds significantly ($p<0.05$) affect L, a, b color values of the tehina samples. While L color values decreased for all power levels with increasing exposure time, a and b values increased. Color parameters show that an increase in roasting time led to an increase in brown color products for all samples. Our results show similarities with those of Yoshida & Takagi (24). They found that, increasing the roasting time lead to markedly increase the red value (a) of the sample. Another investigation on the role of roasting in color development during roasting of hazelnuts show similarities with our results (8). They found that L value of hazelnut samples decreased with roasting time, while a and b increased.

In this present study, generally the L color value of the samples at different roasting depths increased with increasing microwave power (Figure 1). On the other hand, a and b values decreased with increasing power

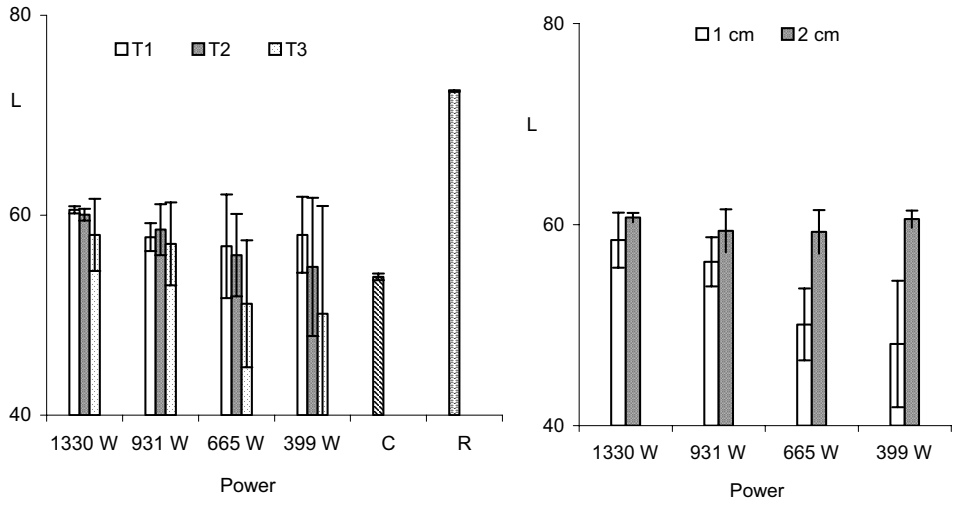

Figure 1. Changes in L color values (mean±standart deviation) of tehina prepared from sesame seeds roasted in a microwave oven (2450 MHz frequency with the powers of 1330, 931, 665 and 399 W) at different exposure time (T1, T2 and T3 on the graphs represent the different exposure times of each power, see Table 1 about experimental design) and seeds depth. C: Conventional, R: Raw (Unroasted).

(Figure 2, Figure 3). The L color value of the tehina from the seeds roasted in depth of 2 cm were higher than those roasted in the depth of 1 cm. In contrast, the a and b color values of the tehina from the seeds roasted at 1 cm depth were higher than those roasted in the depth of 2 cm.

The hue angle (h), chroma (C) and net color differences were calculated in order to compare the degree of browning induced by the conventional roasting method and the microwave applications. According to their a

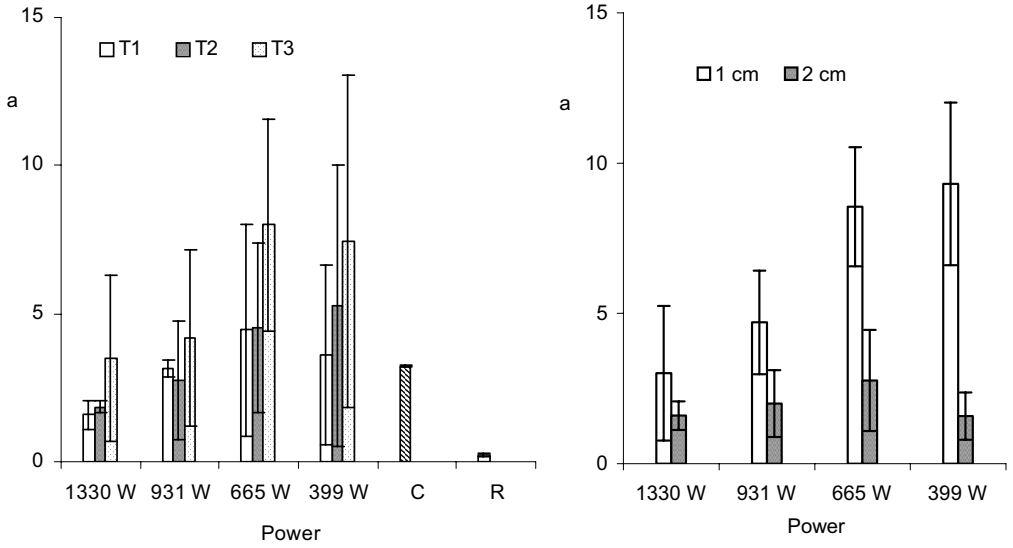

Figure 2. Changes in a color values (mean±standart deviation) of tehina prepared from sesame seeds roasted in a microwave oven (2450 MHz frequency with the powers of 1330, 931, 665 and 399 W) at different exposure time (T1, T2 and T3 on the graphs represent the different exposure times of each power) and seeds depth. C: Conventional, R: Raw (Unroasted).

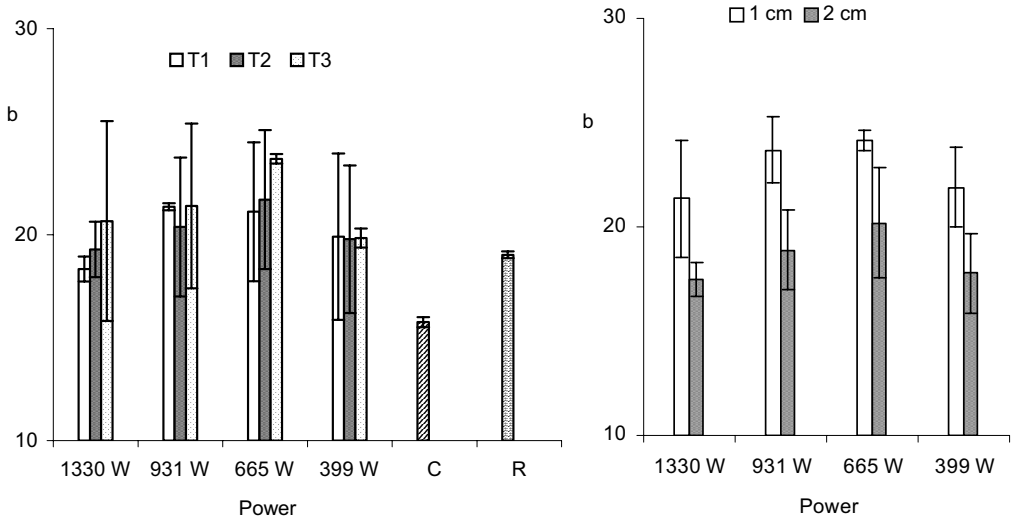

Figure 3. Changes in b color values (mean±standart deviation) of tehina prepared from sesame seeds roasted in a microwave oven (2450 MHz frequency with the powers of 1330, 931, 665 and 399 W) at different exposure (T1, T2 and T3 on the graphs represent the different exposure times of each power) time and seeds depth. C: Conventional, R: Raw (Unroasted).

color values, the samples, roasted between 4 and 5 min at 1330 W, 4 and 6 min at 931 W at 1 cm seed depth and those roasted for 4 min at 931 W and between 12 and 14 min at 665 W at 2 cm seed depth, were similiar to the a value of the conventionally roasted sample. When comparing the net color differences of the microwaved sample with the conventionally roasted sample (DE1), the highest color difference values were observed for samples roasted 399 W and 665 W at 1 cm seed depth. Similar results were observed when comparing the net color differences of the microwaved sample with the unroasted sample (DE2).

The present study showed that sesame seeds were roasted at different power levels and for different times in a microwave oven (2450 MHz frequency), some samples were acceptable in terms of color quality and

moisture content when compared with the conventionally processed sample. Considering the savings, both in energy and time, microwave roasting at 931 and 1330 W could be considered as an alternative roasting process. It can also be said that samples roasted at 1 cm seed depth was superior to those roasted at 2 cm seed depth with respect to the typically desired aroma.

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REFERENCES

1. Anonymous 2005. *Fao Production Year Book*, Rome (http://www.fao.org).
2. Salunkhe DK, Chavan JK, Adsule RN, Kadam SS. 1992. *World Oilseeds Chemistry, Technology and Utilization*. Van Nostrand Reinhold, 554 p, New York.
3. Yoshida H. 1994. Composition and quality characteristics of sesame seed (*Sesamum indicum*) oil roasted at different temperatures in an electric oven. J. Sci. Food Agric, 65: 331-336.
4. Abou-Gharbia HA, Shahidi F, Shehata AAY, Youssef M. 1997. Effects of processing on oxidative stability of sesame oil extracted from intact and dehulled seeds. JAOCS, 74 (3): 215-221.
5. Lindler P, Kinsella JE. 1991. Study of hydration process in tehina. Food Chem, 42: 301-319.
6. Yen GC, Shyu SL, Lin TC. 1986. Studies on improving the processing of sesame oil I. Optimum processing conditions. J. Food Sci, 13: 198-211.
7. Özdemir M, Devres O. 2000. Analysis of color development during roasting of hazelnuts using response surface methodology. J. Food Eng, 45: 17-24.
8. Fallico B, Arena E, Zappala M. 2003. Roasting of hazelnuts. Role of oil in colour development and hydroxymethylfurfural formation. Food Chem, 81: 569-573.
9. Yen GC. 1990. Influence of seed roasting process on the changes in composition and quality of sesame (*Sesamum indicum*) oil. J. Sci. Food Agric, 50: 563-570.
10. Mudgett RE. 1989. Microwave food processing. Food Tech, 1: 117-126.
11. Ramaswamy H, Van De Voort FR. 1990. Microwave applications in food processing. Can Inst Food Sci Technol J, 23 (1): 17-21.
12. Decareau RV, Peterson RA. 1986. Microwave processing and engineering (pp. 37-87), Ellis Horwood, Chichester.
13. Mudgett RE. 1988. Electromagnetic energy and food processing. J Microwave Power Electromagn Energy, 23 (4): 225-230.
14. Mudgett RE. 1990. Developments in microwave food processing. In *Biotechnology and Food Process Engineering*, HG Schwartzberg and MA Rao (eds), pp. 359-404, Marcel Dekker Inc., New York.
15. Eves G. 1996. Industrial microwave food processing. *Microwave World*, 17 (1): 15-18.
16. Yen GC, Shyu SL. 1989. Oxidative stability of sesame oil prepared from sesame seed with different roasting temperatures. Food Chem, 31: 215-224.
17. Shahidi F, Aishima T, Abou-Gharbia HA, Youssef M, Shehata AAY. 1997. Effect of processing on flavor precursor amino acids and volatiles of sesame paste (tehina). JAOCS, 74 (6): 667-678.
18. Yoshida H, Kajimato G. 1994. Microwave heating affects composition and oxidative stability of sesame (*Sesamum indicum*) oil. J. Food Sci, 59 (3): 613-616.
19. Yoshida H, Shigezaki J, Takagi S, Kajimato G. 1995. Variations in the composition of various acyl lipids, tocopherols and lignans in sesame seeds oils roasted in a microwave oven. J. Sci. Food Agric, 68: 407-415.
20. Abou-Gharbia HA, Shehata AAY, Youssef M, Shahidi F. 1996. Oxidative stability of sesame paste (tehina). J. Food Lipids, 3: 129-137.
21. AOAC 1990. *Official Methods of Analysis*. 15th ed. Asooc. Official Anal. Chemists, Washington.
22. Seve R. 1991. New formula for the computation of CIE 1976 hue difference. Color Res. Appl, 16: 217-218.
23. Anonymous 1977. *Tahin. TS-2589*. TSE. Ankara, Turkey.
24. Yoshida H, Takagi S. 1997. Effects of seed roasting temperature and time on the quality characteristics of sesame (*Sesamum indicum*) oil. J Sci Food Agric, 75: 19-26.
25. Potter NN. 1986. *Food Science*. Fourth Edition. Published by Van Nostrand Reinhold, 608 p, New York.